FORM PTO-1390 (REV. 11-2000)	U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER P-224
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371			U S APPLICATION NO. (if known, see 37 CFR 1.5 09/869145
INTERNATIONAL APPLICATION NO. PCT/KR00/01226	INTERNATIONAL FILING DATE October 27, 2000		PRIORITY DATE CLAIMED October 27, 1999

TITLE OF INVENTION

Method for Extracting Zernike/Pseudo-Zernike Moment

APPLICANT(S) FOR DO/EO/US

Hoel Wyul KIM and Sun Kyoo HWANG

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.

4. [ ] The US has been elected by the expiration of 19 months from the priority date (Article 31).

5. [ ] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
    a. [ ] is attached hereto (required only if not communicated by the International Bureau).
    b. [ ] has been communicated by the International Bureau.
    c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).

6. [x] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
    a. [x] is attached hereto.
    b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).

7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
    a. [ ] are attached hereto (required only if not communicated by the International Bureau).
    b. [ ] have been communicated by the International Bureau.
    c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
    d. [ ] have not been made and will not be made.

8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).

9. [x] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [x] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. [x] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. [x] A FIRST preliminary amendment.

14. [ ] A SECOND or SUBSEQUENT preliminary amendment.

15. [ ] A substitute specification.

16. [ ] A change of power of attorney and/or address letter.

17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.

18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).

19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

20. [x] Other items or information:
    International Search Report
    PCT Request

	INTERNATIONAL APPLICATION NO PCT/KR00/01226	ATTORNEY'S DOCKET NUMBER P-224

U.S. APPLICATION NO. 09/887145

		CALCULATIONS PTO USE ONLY
21. [x] The following fees are submitted: **BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):**		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1000.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $860.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $710.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) $690.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00		

ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	10 - 20 =	0	x $18.00	$	
Independent claims	4 - 3 =	1	x $80.00	$ 80.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $270.00	$	

TOTAL OF ABOVE CALCULATIONS =	$ 940.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +	$	

SUBTOTAL =	$	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$	

TOTAL NATIONAL FEE =	$940.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +	$ 40.00	

TOTAL FEES ENCLOSED =	$980.00	
	Amount to be refunded:	$
	charged:	$

a. [X] A check in the amount of $ ___980.00___ to cover the above fees is enclosed.   ck#00643

b. [X] Please charge my Deposit Account No. _16-0607_   in the amount of $ ~~deficiently~~ any to cover the above fees.
A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
overpayment to Deposit Account No. _16-0607_ . A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card
information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR
1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

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SIGNATURE

Daniel Y.J. Kim
NAME

Reg. No. 36,186
REGISTRATION NUMBER

Docket No.:   P-224   PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of   :
                                              :
Hoel Wyul KIM and Sun Kyoo HWANG   :
                                              :
Serial No.: New U.S. National Phase of   :
   Intl. Appln. No. PCT/KR00/01226   :
                                              :
International Filing Date: October 27, 2000   :
U.S. Natl. Phase Filing Date: June 26, 2001   :

For: METHOD FOR EXTRACTING ZERNIKE/PSEUDO-ZERNIKE
        MOMENT

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D. C. 20231

Sir:

        Prior to initial examination on the merits, please amend the above-identified

application as follows:

IN THE SPECIFICATION:

        Prior to the first paragraph of the application at page 1, please insert the following

paragraph:

        --This application claims priority to PCT/KR00/01226, filed October 27, 2000,

which claimed priority to Korean Patent Application No. 46916/1999, filed October 27,

1999.--

IN THE CLAIMS:

Please amend claims 3 and 8 as follows:

Amended Claims With Mark-ups to Show Changes Made

3.   (Amended) The method according to claim 1 [or 2], wherein the step of obtaining a pixel value of the input image comprises the steps of:

adjusting the input image to the size fo the Zernike/Pseudo-Zernike moment basis function; and

obtaining the pixel value of the input image by projecting the input image of which the size is adjusted onto the quadrant by using x-axis symmetry, y-axis symmetry, and origin symmetry.

8.   (Amended) The method according to claim 6 [or 7], wherein the symmetry of the Zernike/Pseudo-Zernike moment basis function is the symmetry of x-axis, y-axis, and origin.

Clean Set of Amended Claims

3.   (Amended) The method according to claim 1, wherein the step of obtaining a pixel value of the input image comprises the steps of:

adjusting the input image to the size fo the Zernike/Pseudo-Zernike moment basis function; and

obtaining the pixel value of the input image by projecting the input image of which the size is adjusted onto the quadrant by using x-axis symmetry, y-axis symmetry, and origin symmetry.

8.   (Amended) The method according to claim 6, wherein the symmetry of the Zernike/Pseudo-Zernike moment basis function is the symmetry of x-axis, y-axis, and origin.

REMARKS

Claims 1-10 are pending. The specification and claims 3 and 8 have been amended to eliminate the multiple dependency. Prompt examination and allowance in due course are respectfully solicited.

Respectfully submitted,
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Date: June 26, 2001

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METHOD FOR EXTRACTING ZERNIKE/PSEUDO-ZERNIKE MOMENT

TECHNICAL FIELD

The present invention relates to a method for extracting a Zernike/Pseudo-Zernike moment, and in particular, to a method for extracting a Zernike/Pseudo-Zernike moment by using the symmetry of a Zernike/Pseudo-Zernike moment basis function and computer readable recording medium on which a program implementing the same method is recorded.

BACKGROUND ART

In the conventional art, since a Zernike/Pseudo-Zernike moment includes an orthogonal basis function, it shows the characteristics of an image more efficiently than a geometric moment, Legendre moment, rotational moment and the like. On the contrary, a method for extracting a Zernike/Pseudo-Zernike moment has the following problem.

The method for extracting a Zernike/Pseudo-Zernike moment according to the conventional art includes the method for storing the result of repeated calculations on a look-up table and using the stored result in extracting a moment.

However, the above method used in extracting a moment requires much moment extraction time, and a large amount of memory utilization necessary for memory extraction is needed in order to store the look-up table.

On the other hand, another conventional method includes an

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approximation method for approximating a Zernike/Pseudo-Zernike moment basis function in a square shape.

However, the above method has a problem that it is impossible to extract an accurate moment for an image, though a moment extraction speed

5   can be increased.

DISCLOSURE OF THE INVENTION

Therefore, it is an object of the present invention to provide a method for extracting a Zernike/Pseudo-Zernike moment by using the symmetry of

10   a Zernike/Pseudo-Zernike moment basis function for the purposes of rapid moment extraction and decrease in memory utilization and computer readable recording medium on which a program implementing the same method is recorded.

It is another object of the present invention to provided a method for

15   extracting a Zernike/Pseudo-Zernike moment by using the symmetry of a Zernike/Pseudo-Zernike moment basis function.

In order to achieve the above-described objects of the present invention, there is provided a method for extracting a Zernike/Pseudo-Zernike moment for an input image according to the present invention, which includes

20   the steps of: generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on a plane cartesian coordinates; obtaining a pixel value of the input image by projecting the input image onto the quadrant; and multiplying each pixel value of the input image by the moment basis function corresponding to the pixel position and then summing the results thereof.

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In addition, there is provided a method for extracting a Zernike/Pseudo-Zernike moment for an input image according to the present invention, which includes the steps of: generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on a plane orthogonal coordinates;

5 generating a Zernike/Pseudo-Zernike moment for all quadrants from the a Zernike/Pseudo-Zernike moment basis function on the quadrant by using the symmetry of a Zernike/Pseudo-Zernike moment; obtaining a pixel value of the input image; and multiplying each pixel value of the input image with the moment basis function corresponding to the pixel position and then summing

10 the results thereof.

In addition, there is provided a computer readable recording medium on which a program implementing the same method is recorded, which includes the functions of: generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on a plane orthogonal coordinates in an image

15 recognition system having a processor in order to extract a Zernike/Pseudo-Zernike moment; obtaining a pixel value of the input image by projecting the input image onto the quadrant; and multiplying each pixel value of the input image with the moment basis function corresponding to the pixel position and then summing the results thereof.

20 In addition, there is provided a computer readable recording medium on which a program implementing the same method is recorded, which includes the functions of: generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on a plane orthogonal coordinates in an image recognition system having a processor in order to extract a Zernike/Pseudo-

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Zernike moment; generating a Zernike/Pseudo-Zernike moment for all quadrants from the a Zernike/Pseudo-Zernike moment basis function on the quadrant by using the symmetry of a Zernike/Pseudo-Zernike moment; obtaining a pixel value of the input image; and multiplying each pixel value

5   of the input image with the moment basis function corresponding to the pixel position and then summing the results thereof.

Additional advantages, objects, and features of the invention will become more apparent from the description which follows.

10   **BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 is a flow chart illustrating a method for extracting a Zernike/Pseudo-Zernike moment according to a first embodiment of the present invention;

Figure 2 is a flow chart illustrating a method for generating a

15   Zernike/Pseudo-Zernike moment according to a second embodiment of the present invention;

Figure 3 is a view explaining symmetry with y=x, x-axis, y-axis, and origin;

Figures 4A and 4B are explanatory views of a Zernike moment basis

20   function in the case that a repetition (m) is an even number;

Figures 5A and 5B are explanatory views of a Zernike moment basis function in the case that a repetition (m) is an odd number; and

Figures 6A and 6B are explanatory views of Zernike moment extraction from an input image.

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MODES FOR CARRYING OUT THE PREFERRED EMBODIMENTS

The preferred embodiment of the present invention will now be described with reference to the accompanying drawings.

Figure 1 is a flow chart illustrating a method for extracting a Zernike/Pseudo-Zernike moment according to a first embodiment of the present invention.

As illustrated therein, the method for extracting a moment includes the steps of: obtaining a Zernike/Pseudo-Zernike moment basis function in a first quadrant in step 101; obtaining a pixel value an input image in step 102; and extracting a Zernike/Pseudo-Zernike moment by multiplying the moment basis function with the pixel value of the input image in step 103.

The step 101 of obtaining a Zernike/Pseudo-Zernike moment basis function in a quadrant will now be described.

First, the real radial polynomial of a Zernike moment and the real radial polynomial of a Pseudo-Zernike moment are obtained by using mathematical formulas 1 and 2 in step 104.

Sine the real radial polynomial of the Zernike/Pseudo-Zernike moment is orthogonal in a unit circle of $x^2 + y^2 = 1$, information redundancy is small.

The real radial polynomial $Rnm'(\rho)$ of the Zernike moment is expressed by mathematical formula 1.

[Mathematical Formula 1]

$$\text{Rnm}(\rho) = \sum_{s=0}^{(n-m)/2} (-1)^s \frac{(n-s)!}{s!(\frac{n+|m|}{2}-s)!(\frac{n-|m|}{2}-s)!} \, \rho^{(n-2s)}$$

5

In addition, the real radial polynomial Rnm(ρ) of the Pseudo-Zernike moment is expressed by mathematical formula 2.

[Mathematical Formula 2]

$$\text{Rnm}(\rho) = \sum_{s=0}^{n=m} (-1)^s \frac{(2n+1-s)!}{s!(n-m-s)!(n-m+1-s)!} \text{p}^{(n-s)}$$

5

Here, n is an order, m is a repetition, and n and m must satisfy n - | m | = even number and | m | ≤ n.

It is checked if the repetition(m) is an even number, i.e., m=2k in step 105. If the repetition(m) is an even number, a Zernike/Pseudo-Zernike basis function is obtained in step 107 by using y=x symmetry in step 106.

A Zernike/Pseudo-Zernike basis function with an order of n and a repetition of m is expressed by mathematical formula 3.

[Mathematical Formula 3]

Vnm(x,y) = Rnm(ρ) $^{e^{jm\theta}}$ = Rnm(ρ) cosm Θ +j Rnm(ρ) sinm Θ

15 = real part + j imaginary part

Here, with respect to Vnm(x,y), the polynomial Rnm(ρ) is multiplied by $^{e^{jm\theta}}$, $^{e^{jm\theta}}$ term is transformed into (cosmΘ + j sinmΘ) by using Fourier Formula.

Here, the cost term and the sin term has a specific symmetry in a Cartesian coordinate system, Vnm(x,y) also has a specific symmetry(refer to Figures 4A through 5B).

The step of obtaining a pixel value of an input image in step 102 will now be explained below(refer to Figures 6A and 6B).

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The pivot point of the input image is calculated to be adjusted to a unit circle size in step 108. Then, the pixel value of each point is obtained by projecting points existing in a fourth quadrant, second quadrant, and third quadrant by using x-axis symmetry, y-axis symmetry, and origin symmetry in step 109.

Here, the reason why the input image is adjusted to the size of a unit circle centering on the origin is that a Zernike/Pseudo-Zernike moment basis function is orthogonal in the unit circle.

The step of extracting a Zernike/Pseudo-Zernike moment by multiplying the moment basis function by a pixel value of an input image in step 103 will now be explained as follows.

The Zernike/Pseudo-Zernike moment is obtained by multiplying each moment basis function by the pixel value of the input image in step 110, and then summing the results thereof in step 111(refer to Figures 6A and 6B).

This will be mathematically expressed by Mathematical Formula 4, and the Zernike/Pseudo-Zernike moment is a complex number.

[Mathematical Formula 4]

$$\text{Anm} = \frac{n+1}{k} \sum_x \sum_y f(x,y) Vnm^*(x,y)$$

Here, * represents a complex conjugate.

Generally, the Zernike/Pseudo-Zernike moment is considered the projection of the Zernike/Pseudo-Zernike basis function of the input image(refer to Figures 6A and 6B).

Figure 2 is a flow chart illustrating a method for generating a Zernike/Pseudo-Zernike moment according to a second embodiment of the

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present invention.

As illustrated therein, the step of generating a Zernike/Pseudo-Zernike moment basis function in a first quadrant in steps 201 through 204 is the same as step 101 of Figure 1.

5   In addition, the Zernike/Pseudo-Zernike moment basis function in the remaining second, third, and fourth quadrants is obtained by applying x-axis symmetry, y-axis symmetry, and origin symmetry to the Zernike/Pseudo-Zernike moment basis function in the first quadrant as obtained in steps 201 through 204.

10   Moreover, unlike Figure 1, the pixel value of the input image is obtained for all the four quadrants without projecting the input image onto the first quadrant. Then, each pixel value is multiplied by the Zernike/Pseudo-Zernike moment basis function corresponding to the position of the pixel, and then the results thereof are added, thereby obtaining the Zernike/Pseudo-Zernike moment for the input image.

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Figure 3 is a view explaining symmetry with y=x, x-axis, y-axis, and origin.

As illustrated therein, the symmetric points of a point P1(a,b) existing in the Cartesian coordinate system includes the symmetric point of x-axis, symmetric point of y-axis, symmetric point of the origin, and symmetric point of y=x.

20

The coordinates and phase angles of the symmetric points in the Cartesian coordinate system are shown in Table 1.

In obtaining Vnm(x,y) in the coordinates disposed in the symmetric

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points, the symmetry of cosmθ and sinmθ is very important. Here, θ
represents the angle between each point and a horizon line.

【Table 1】

Reference for symmetric point	coordinate	$\theta = \tan^{-1}(y/x)$
Reference point	P1 = (a, b)	θ
y-axis symmetry	P2 = (-a, b)	$\pi - \theta$
Origin symmetry	P3 = (-a,-b)	$\pi + \theta$
x-axis symmetry	P4 = (a,-b)	$-\theta$
Y=x symmetry	P1 ´=(b, a)	$\pi/2 - \theta$

Figures 4A and 4B are explanatory views of a Zernike moment basis
function in the case that a repetition (m) is an even number.

As illustrated therein, the shape of the Zernike moment basis function
in the case that the repetition(m) is an even number is shown.

With respect to each symmetric point, like Table 1, when the angle
between each point and a horizon line, i.e.,θ is changed, the symmetry of
cosmθ and sinm θ varies according to whether the repetition(m) is an even
number or odd number. Here, the shape of the Zernike moment basis function
in the case that the repetition(m) is an even number is explained.

Figure 4A illustrates the real part of the Zernike moment basis function,
and Figure 4B illustrates the imaginary part of the Zernike moment basis
function.

The Zernike moment basis function has a value between −1 and 1.
The range of the value of the Zernike moment basis function is divided into
256 parts, in which a value close to −1 is denoted by black, while a value
close to 1 is denoted by white.

As illustrated therein, the Zernike moment basis function has symmetry of a specific type for the x-axis, y-axis, and origin. Such symmetry is caused by the change in θ as shown in Table 1, which can be put in order as shown in Table 2.

5   【Table 2】

Reference for Symmetric Point	Coordinate	Real part	Imaginary Part
Reference Point	P1 = (a, b)	R	I
y-axis Symmetry	P2 = (-a, b)	R	-I
Origin symmetry	P3 = (-a,-b)	R	I
x-axis Symmetry	P4 = (a,-b)	R	-I

In the case that the repetition(m) is an even number, y=x also has symmetry. That is, the case of m=4k and the case of m=4k+2 has different types of symmetry.

10   In case of m=4k, the real part has the same value in symmetry with y=x, while the imaginary part has a value multiplied by −1.

In case of m=4k+2, both real part and imaginary part has a value multiplied by −1 in symmetry with y=x.

The above description will be also adapted to the Pseudo-Zernike

15   moment basis function.

Figures 5A and 5B are explanatory views of a Zernike moment basis function in the case that a repetition (m) is an odd number.

As illustrated therein, the shape of the Zernike moment basis function in the case that the repetition(m) is an odd number is explained.

20   With respect to each symmetric point, like Table 1, when the angle

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between each point and a horizon line, i.e.,θ is changed, the symmetry of cos$m\theta$ and sin$m\theta$ varies according to whether the repetition(m) is an even number or odd number. Here, the shape of the Zernike moment basis function in the case that the repetition(m) is an odd number is explained.

Figure 5A illustrates the real part of the Zernike moment basis function, and Figure 5B illustrates the imaginary part of the Zernike moment basis function.

The Zernike moment basis function has a value between −1 and 1. The range of the value of the Zernike moment basis function is divided into 256 parts, in which a value close to −1 is denoted by black, while a value close to 1 is denoted by white.

The symmetry in case of m=2k+1 is caused by the change in θ as shown in Table 1, which can be put in order as shown in Table 4.

【Table 3】

Reference for symmetric point	Coordinate	Real part	Imaginary part
Reference point	P1 = (a, b)	R	I
Y-axis symmetry	P2 = (-a, b)	-R	I
Origin symmetry	P3 = (-a,-b)	-R	-I
X-axis symmetry	P4 = (a,-b)	R	-I

The above description will be also adapted to the Pseudo-Zernike moment basis function.

Figures 6A and 6B are explanatory views of Zernike moment extraction from an input image.

As illustrated therein, Figure 6A illustrates the imaginary part of the Zernike moment basis function in case of n=m=3, and Figure 6B illustrates

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an input image adjusted to the size as in Figure 6A.

The Zernike/Pseudo- Zernike moment is obtained by multiplying each pixel value of the input image by the Zernike/Pseudo- Zernike moment basis function corresponding to the position of the pixel and then summing the

5   results thereof.

The method for obtaining the Zernike moment for the input image(Figure 6B) in the first quadrant only will be described, for example, in detail.

In the case that an order is 3(n=3) and a repetition is 3(m=3), the

10   Zernike moment is obtained by multiplying each pixel value of the input image(Figure 6B) by the Zernike moment basis function corresponding to the position of the pixel, and summing the results thereof.

The pixel values of four points(denoted by black, round points on the drawings) having symmetry are represented as O, P, Q, and R. If the Zernike

15   moment basis function corresponding to the position of pixel O is A, the Zernike moment basis functions corresponding to the positions of the remaining pixels P, Q, and R are A, -A, and –A, respectively, by x-axis symmetry, y-axis symmetry, and origin symmetry.

Here, with respect to the moment basis function and the pixel value of

20   the input image, in case of binary image, black portions has a pixel value of 1, white portions has a pixel value of 0, or vice versa. On the other hand, in case of grayscale image, the pixel value is recognized a value between 0 and 255.

At this time, the Zernike moment(A33) for the input image is obtained

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by [Mathematical Formula 5]

$$\text{Zernike moment}(A33) = O*(A) + P*(A) + Q*(-A) + R*(-A)$$

If Mathematical Formula 5 is changed to Mathematical Formula 6, the number of multiply operations is reduced from 4 to 1.

[Mathematical Formula 6]

$$\text{Zernike moment}(A33) = (O + P - Q - R) * A$$

In Mathematical Formula 6, the operation of (O + P - Q - R) means that the second, third, and fourth quadrants are projected onto the first quadrant.

Mathematical Formula 6 has an order of +, +, -, -. This order is changed according to the order(n) and repetition(m). In this way, the information of the input image in all the four quadrants is concentrated in the first quadrant. Thus, it is possible to rapidly obtain a Zernike moment by multiplying the information in the first quadrant by the Zernike moment basis function.

As the present invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its spirit and scope as defined in the appended claims, and therefore all changes and modifications that fall within the meets and bounds of the claims, or equivalences of such meets and bounds are therefore intended to be embraced by the appended claims.

INDUSTRIAL APPLICABILITY

As described above in detail, it is possible to extract a Zernike/Pseudo-Zernike moment in real time according to the embodiments of the present invention.

In addition, in the present invention, system loads can be reduced more substantially by decreasing memory utilization during moment extraction to 1/4, as compared to the conventional art.

CLAIMS

1.   A method for extracting a Zernike/Pseudo-Zernike moment for an input image, comprising the steps of:

generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on plane Cartesian coordinates;

obtaining a pixel value of the input image by projecting the input image onto the quadrant; and

multiplying each pixel value of the input image by the moment basis function corresponding to the pixel position and then summing the results thereof.

2.   The method according to claim 1, wherein the step of generating a basis function comprises the steps of:

obtaining a moment radial polynomial according to the change in order and repetition and checking if the repetition is an even number;

generating the Zernike/Pseudo-Zernike moment basis function in the quadrant by using the symmetry of a linear function passing the origin and having an absolute value of its slope of 1, if the repetition is an even number; and

generating the Zernike/Pseudo-Zernike moment basis function in the quadrant without using the symmetry as in the above step, if the repetition is an odd number.

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3. The method according to claim 1 or 2, wherein the step of obtaining a pixel value of the input image comprises the steps of:

adjusting the input image to the size of the Zernike/Pseudo-Zernike moment basis function; and

obtaining the pixel value of the input image by projecting the input image of which the size is adjusted onto the quadrant by using x-axis symmetry, y-axis symmetry, and origin symmetry.

4. The method according to claim 1, wherein the predetermined quadrant is a first quadrant.

5. The method according to claim 2, wherein the linear function passes the origin and has a slope of +1(i.e., y=x).

6. A method for extracting a Zernike/Pseudo-Zernike moment for an input image, comprising the steps of:

generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on a plane orthogonal coordinates;

generating a Zernike/Pseudo-Zernike moment for all quadrants from the a Zernike/Pseudo-Zernike moment basis function on the quadrant by using the symmetry of a Zernike/Pseudo-Zernike moment;

obtaining a pixel value of the input image; and

multiplying each pixel value of the input image with the moment basis function corresponding to the pixel position and then summing the results

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thereof.

7. The method according to claim 6, wherein the step of generating a basis function comprises the steps of:

obtaining a moment radial polynomial according to the change in order and repetition and checking if the repetition is an even number;

generating the Zernike/Pseudo-Zernike moment basis function in the quadrant by using the symmetry of a linear function passing the origin and having an absolute value of its slope of 1, if the repetition is an even number; and

generating the Zernike/Pseudo-Zernike moment basis function in the quadrant without using the symmetry as in the above step, if the repetition is an odd number.

8. The method according to claim 6 or 7, wherein the symmetry of the Zernike/Pseudo-Zernike moment basis function is the symmetry of x-axis, y-axis, and origin.

9. A computer readable recording medium on which a program implementing the same method is recorded, comprising the functions of:

generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on a plane orthogonal coordinates in an image recognition system having a processor in order to extract a Zernike/Pseudo-Zernike moment;

obtaining a pixel value of the input image by projecting the input image

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onto the quadrant; and

multiplying each pixel value of the input image with the moment basis function corresponding to the pixel position and then summing the results thereof.

5

10.   A computer readable recording medium on which a program implementing the same method is recorded, comprising the functions of:

generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on a plane orthogonal coordinates in an image recognition system having a processor in order to extract a Zernike/Pseudo-Zernike moment;

generating a Zernike/Pseudo-Zernike moment for all quadrants from the a Zernike/Pseudo-Zernike moment basis function on the quadrant by using the symmetry of a Zernike/Pseudo-Zernike moment;

obtaining a pixel value of the input image; and

multiplying each pixel value of the input image with the moment basis function corresponding to the pixel position and then summing the results thereof.

ABSTRACT

The present invention relates to a method for extracting a Zernike/Pseudo-Zernike moment, and in particular, to a method for extracting a Zernike/Pseudo-Zernike moment by using the symmetry of a Zernike/Pseudo-Zernike moment basis function and computer readable recording medium on which a program implementing the same method is recorded. The method of the invention includes the steps of: generating a Zernike/Pseudo-Zernike moment in a predetermined quadrant on plane Cartesian coordinates; obtaining a pixel value of the input image by projecting the input image onto the quadrant; and multiplying each pixel value of the input image by the moment basis function corresponding to the pixel position and then summing the results thereof. Therefore, it is possible to extract a Zernike/Pseudo-Zernike moment in real time. In addition, system loads can be reduced more substantially by decreasing memory utilization during moment extraction to 1/4, as compared to the conventional art.

FIG. 1

START

101
104 — CALCULATE ZERNIKE/
PSEUDO-ZERNIKE
POLYNOMIAL $R_{nn(\rho)}$

105 — m=2k — NO

YES

106 — USE Y=X SYMMETRY
107

GENERATE ZERNIKE/PSEUDO-
ZERNIKE MOMENT BASIS FUNCTION
$V_{nn(x,y)}$

102
ADJUST INPUT IMAGE TO 108
TO SIZE OF
UNIT CIRCLE

109
GENERATE PIXEL VALUE OF EACH
POINT OF INPUT IMAGE
BY PROJECTING POINTS EXISTING
IN X-AXIS, Y-AXIS, AND ORIGIN
SYMMETRIES ONTO FIRST QUADRANT

ZERNIKE/PSEUDO-ZERNIKE 110
MOMENT BASIS FUNCTION
X PIXEL VALUE OF
INPUT IMAGE

103

GENERATE ZERNIKE/PSEUDO- 111
ZERNIKE MOMENT (A_{nn})

END

FIG. 2

```
                    ┌─────────┐
                    │  START  │
                    └─────────┘
                         │
          ┌──────────────────────────────┐
 201 ─────│ CALCULATE ZERNIKE/            │
          │ PSEUDO-ZERNIKE               │
          │ POLYNOMIAL $R_{nn}(\rho)$     │
          └──────────────────────────────┘
                         │
                        ╱ ╲          NO
          202 ───────< m=2k >──────────────┐
                        ╲ ╱                 │
                         │ YES              │
          ┌──────────────────────────┐     │
 203 ─────│ USE Y=X SYMMETRY         │     │
          └──────────────────────────┘     │
                         │                  │
          ┌──────────────────────────────┐ │
          │ GENERATE ZERNIKE/PSEUDO-      │ │
 204 ─────│ ZERNIKE MOMENT BASIS FUNCTION │◄┘
          │        $V_{nn}(x,y)$          │
          └──────────────────────────────┘
                         │
          ┌──────────────────────────────┐
 205 ─────│ USE X-AXIS,Y-AXIS,AND         │
          │    ORIGIN SYMMETRY            │
          └──────────────────────────────┘
                         │
          ┌──────────────────────────────┐
          │ GENERATE ZERNIKE/PSEUDO-      │
 206 ─────│ ZERNIKE MOMENT BASIS FUNCTION │
          │        $V_{nn}(x,y)$          │
          └──────────────────────────────┘
                         │
                    ┌─────────┐
                    │   END   │
                    └─────────┘
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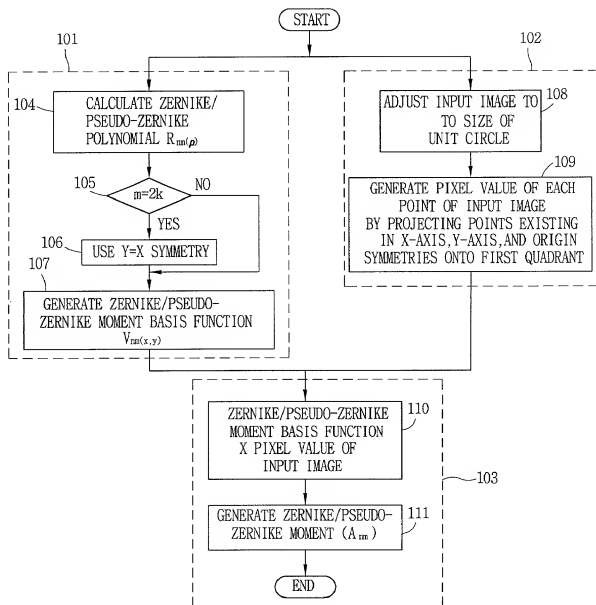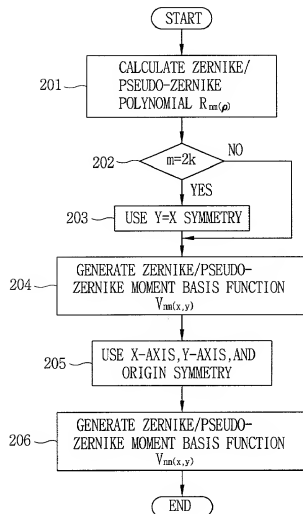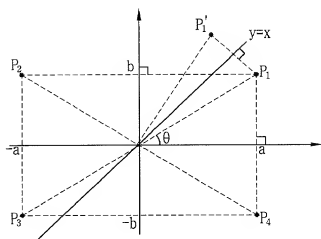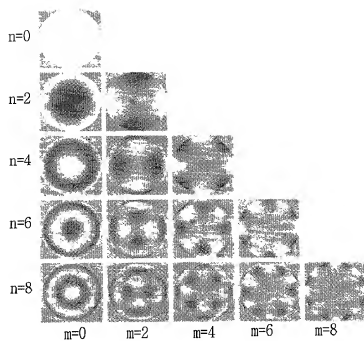
FIG. 3

FIG. 4A
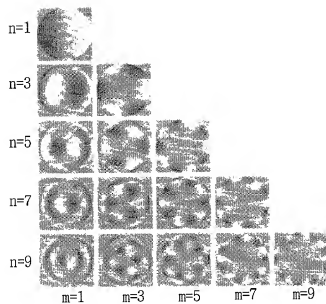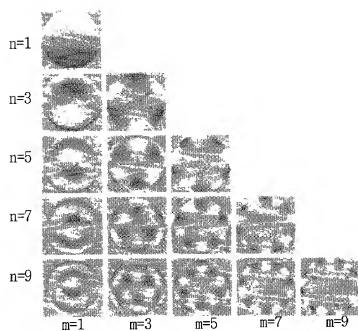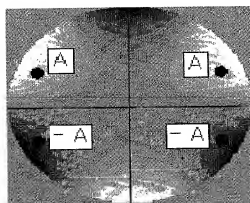

FIG. 4B

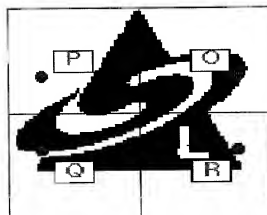FIG. 5A

FIG. 5B

FIG. 6A

FIG. 6B

Docket No.: _____

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter claimed and for which a patent is sought on the invention entitled METHOD FOR EXTRACTING ZERNIKE/PSEUDO-ZERNIKE MOMENT _____, the

specification of which

[X] is attached hereto   [ ] was filed on _____ as Application Serial No. _____ and was

amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is known to me to be material to patentability in accordance with Title 37, Code of Fed Regulations, Section 1.56(a).

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365 (b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s): Number	Country	Foreign Filing Date Month/Day/Year
46916/1999	Korea	10/27/1999

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s):	Filing Date (Month/Day/Year)

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the pri United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disc information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior applicatio and the national or PCT international filing date of this application.

Prior U. S. Application or PCT Parent Number (if applicable)	Filing Date (Month/Day/Year)	Parent Patent Number
PCT/KR00/01226	10/27/2000	

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorney(s) and/or agent(s):Daniel Y.J. Kim, Registration No. 36,186 and Mark L. Fleshner, Registration No. 34,596; Carl R. Wesolowski, Registration No. 40,372, John C. Eisenhart, Registration No. 38,128, Rene A. Vazquez, Registration No. 38,647; Michael J. Cornelison, Registration No. 40,395; and Stuart I. Smith, Registration No. 42,159; and Carol L. Druzbick, Registration No. 40,287, all of

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with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, and all future correspondence should be addressed to them.

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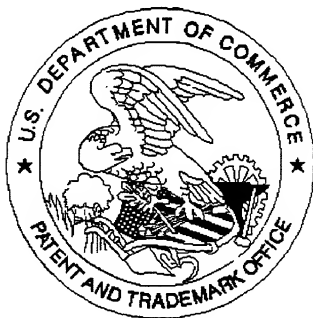Inventor's signature: Date:

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